NABT encourages Letters to the Editor. However, it is not always possible to print all of the letters ABT *receives or to run them in their entirety due to space constraints. The Editor reserves the right to select and edit Letters to the Editor.*

Laws, Hypotheses, Guesses

Dear Editor:

Laws, principles, rules, hypotheses, predictions, guesses. The meanings of these terms have generated considerable discussion (McPherson, 2001; Murray, 2001; Kugler, 2002; Pooth, 2002; Bednekoff, 2003; Colyvan & Ginzburg, 2003; Kinraide & Denison, 2003). Popper (1985: 19), however, advises us never to take "... seriously problems about words and their meanings." He continues, "What must be taken seriously are questions of fact, and assertions about facts: theories and hypotheses; the problems they solve; and the problems they raise." For example, Newton's First Law of Motion—"an object remains at rest or in motion in a straight line at a constant speed in a straight line until acted on by an outside force"—is something that we cannot know by direct evidence, but, nevertheless, tells us much about the observable facts of our experience (Einstein & Infeld, 1938). It makes no difference what we call Newton's assertion about inertial motion (law, premise, hypothesis, guess). The predictions or deductions that follow from it do not change. Nevertheless, we define words in order to facilitate communication. Thus, with that aim, I will offer some definitions.

I begin with a fundamental distinction: the difference between deductive and inductive logic. In deductive logic an argument begins with statements called universal laws (or premises, hypotheses, assumptions). They are assumed to be true without any direct observable evidence. From these laws and some facts that we do know, called the initial conditions, we deduce predictions. For example, with his laws and his knowledge of the period and radius of the moon's orbit, Newton deduced that an apple near the Earth's surface should fall about 16.1 feet in the first second of free-fall. The structure of this kind of argument has been called the deductive-nomological (D-N) model (Hempel & Oppenheim, 1948) and the Popper-Hempel model (Niiniluoto, 1995). Popper (1979: 9, his italics) again warns us, "... we must regard *all laws or theories as hypothetical or conjectural;* that is, as guesses." Einstein's Theory of General Relativity demonstrated that Newton's Laws had always been guesses. Einstein's theory is a guess as well.

Newton's Laws were guesses because they were the inventions of a creative mind, not because Newton or anyone else had ever seen a body moving in a straight line. The laws of a deductive-nomological argument are not generalizations describing observable correlations.

A version of Baconian inductive logic is the logic that characterizes biological thinking. In inductive logic we begin with observations. For example, we observe that warm-blooded animals living in cooler climates tend to be larger than others of the same species (or sometimes even species within a genus) that live in warmer climates. We call this observable correlation Bergmann's Rule. We do not intend it to be universally applicable because we already know that there are exceptions. Nevertheless, the rule does usefully summarize a body of information. We expect to find larger-bodied individuals in cooler climates. This occurs sufficiently often for a physiologist or an evolutionary biologist to wonder why this correlation should be so, which leads to research on adaptations to temperature.

Inductive argument seems not to have the rigorous structure of a deductive-nomological argument, which leads to biologists often confusing "hypothesis" and "prediction" (McPherson, 2001). Suppose that we discover a new species of mammal in the Amazonian rainforest, which is a close relative of a more northern species. Some biologists may "predict" a smaller body size. Others may "hypothesize" a smaller body size. Why the difference? Bergmann's Rule is not a hypothesis or assumption like Newton's Laws because it is not universal. It is, instead, a statement of *fact*: "many populations of warm-blooded animals are of smaller size in warmer climates." We do not know whether the members of the newly discovered population in Amazonia are smaller or larger than in higher latitude populations until we measure them. Emphasizing that we do not know their size, some biologists may say, "I hypothesize that they are smaller." Emphasizing the validity of Bergmann's Rule as a useful generalization, other biologists may say, "I predict they are smaller." Both could be considered correct, but notice that "hypothesize" and "predict" have different meanings in inductive argument than in deductive argument. A hypothesis in a deductive argument is a statement of relationships that cannot be known to be universally true by direct observation but are assumed to be universally true. It is often an imagined relationship, such as Newton's First Law. It can only be tested indirectly by deducing its empirical consequences. When experience contradicts a prediction of a deductive-nomological theory, the theory has been falsified.

In contrast to Newton's First Law, Bergmann's Rule is a statement that we know to be true. The "hypothesis" or "prediction" regarding the body size of the newly discovered mammal in Amazonia is simply its application to a specific case. The "hypothesis" or "prediction" can be tested by direct observation. If the newly discovered population is larger than its relatives at higher latitudes, all we have shown is that our prediction or hypothesis was wrong, but we have not falsified Bergmann's Rule because it is not a universal statement. As Popper (1979: 193) indicated, "Only if we require that explanations shall make use of universal statements or laws of nature (supplemented by initial conditions) can we make progress towards realizing the idea of independent, or non-*ad hoc,* explanations."

Inductive generalizations are established by the enumeration of additional examples (as described in virtually every biology textbook). With few supporting examples, the inductive generalization is called a hypothesis. With a larger set of supporting examples, it is called a theory. With an abundance of supporting examples, it is called a "law." A law in inductive argument, then, is directly supported by an abundance of empirical data, whereas a law in deductive argument is directly supported by none.

In summary, in deductive thinking, there is no question about what is a hypothesis and what is a prediction. In inductive thinking, the distinction is not at all clear. Indeed, if we want to make distinctions, I suggest that "rules" refer to empirical generalizations (e.g., Bergmann's Rule, Cope's Rule, Allen's Rule and many others [Rensch, 1971]), "hypotheses" be limited to statements that are not known and cannot be known to be true by direct observation (for example, Newton's First Law and, in biology, Darwin's Law of Natural Selection), and that "predictions" be limited to those statements that are deduced from universal statements, which are best called laws. The "hypotheses" or "predictions" that follow from an inductive rule, such as Bergmann's, are neither hypotheses nor predictions. They are *probabilistic expectations based on prior experience* rather than logically deduced consequences from universal laws and initial conditions. The use, or misleading use, of these terms is so ingrained in the biologists' lexicon that a change in usage is too much to hope for.

What I can hope is for biologists to know the difference between deductive and inductive thinking and, especially, the benefits and limitations of each. I can hope that biologists will recognize that the terms hypothesis, prediction, and deduction have very different meanings in these different modes of thought. A biologist who makes a prediction from Bergmann's Rule is not applying the same logic as the physicist who makes a prediction from Newton's Laws.

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In Defense of "How We Treat our Relatives"

Dear Editor,

Randy Moore's Editorial, "How We Treat Our Relatives," (October 2003, Volume 65, Number 8, pp. 566-568) was an excellent display of careful moral reasoning regarding the ethical treatment of animals; his letter was met with a critical reply by McInerney, Morrison, and Schrock (April 2004, Volume 66, Number 4, pp. 253-254). Cross & Cross' (2004) comparison of organic and virtual frog dissection was based in moral and pedagogical questions about animal dissection. Here I respond to Moore's critics, thereby defending his position, and reveal a related oversight in the conclusions Cross & Cross draw from their study.

Moore argues that, like humans, many animals are conscious and can feel pain, suffer, and experience emotions. Like us, they are due respect because of these features of their mental lives and the harms that they might endure; minded animals are due the moral consideration due to comparably-minded humans. The many ethicists who have addressed these issues overwhelmingly support

Moore's position. They have argued that that animals' interests—in avoiding pain, suffering and death—must be taken seriously and that this view has the weight of reason on its side (Taylor, 2003).

Moore's critics, however, argued that his Editorial contained "inaccuracies and misconceptions." This is not true. As I will show, it is *their* response that contains the errors. And to offer a caveat parallel to what they offer (p. 253), if their mistakes stand unchallenged, there is a danger that they will be used to hinder students' moral reasoning and critical thinking skills, violate students' moral and legal rights, and impede students' intellectual development. Given these stakes, their claims must be challenged.

First, Moore emphasized evolutionary relations between humans and other animals. His critics responded, "Evolutionary relatedness does not ... translate into moral equivalence between human and other species. ..." (p. 253). True, not *directly,* but evolution suggests that consciousness, sentience, etc. – the basis for moral considerability – overlap between species and, therefore, many animals are due far greater respect, and better treatment, than is ordinarily given to them.

Second, Moore was correct to note that, historically, many scientists have believed that animals do not feel pain. While this is becoming a minority view, it is not clear that this has informed practice and resulted in animals' pains being taken seriously. While some European countries categorically ban certain painful experiments, U.S. experimenters have vigorously lobbied against *any* such restrictions. To suggest that U.S. law and Institutional Animal Care and Use Committees (IACUC) profoundly protect animals from pain is disingenuous and unfaithful to the often painful truths of what happens to animals in procurement and processing for dissection and in laboratories (Regan, 2004).

Third, Moore's critics suggest that since animals lack a sense of justice, interest in developing advanced knowledge, and do not publish in this journal (!) (p. 254), they are less morally valuable than those who can. But disabled, very young and very old humans lack these abilities and interests yet are rightly protected from exploitation by those who do. The critics' suggestion here harkens to a perverse "publish or *literally* perish" principle, not any morally justifiable beliefs and attitudes we ought to cultivate in ourselves or our students.

Finally, the critics' attempts to extend what is true about *some* humans – in terms of their moral and intellectual achievements – to *all* humans, as a basis for their rights, are weak (Nobis, 2004). Humans are not a monolithic group: biologically human cells in a Petri dish lack moral standing and so moral status is not a matter of one's DNA; rather, it is a matter of vulnerability to physical and/or psychological harm. And there is no abstract entity "humanity"; there are *individual* humans (and animals) who have (or lack) the morally-relevant characteristics that Moore and his philosophical allies identify. Their critics' attempts to deny this fail; McInerney, Morrison, and Schrock provide no moral justification of any aspect of the status quo regarding animal use.

Their criticisms are instructive, however, in that they show how ethics and science are similar. Both involve developing and evaluating hypotheses, seeking best explanations, and testing theories and principles for false results. We can reason, and offer evidence, in science and in ethics: Neither is a matter of "mere opinion" as we can show that some views lack support.

Both science and ethics require us to actively seek out the strongest challenges to our views to see how our research and thinking hold up to critical scrutiny. This is where Cross & Cross's (2004) study was inadequate: Their single study found that organic frog dissection was preferable, but over 30 other studies have found that humane alternatives to dissection are pedagogically sound and often superior to dissection (Balcombe 2000, 2001), which they failed to discuss. Unless one shows that these studies are faulty, that animal dissection is acceptable given its moral and financial costs, and that there are no educationally preferable uses of class-time, one is not entitled to the judgment that there should be dissection, all things considered (Nobis, 2002).

If more educators followed Moore's leadership and addressed ethical issues in a more scientific, logical, and evidence-based manner, there would surely be more constructive discussions on these important matters of life and death. As Moore urges, "We should not look away" from these challenging issues: The lives of billions of animals, and our own moral development, are in the balance. Let us make the most of it.

Sincerely,

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On "Genetic Screening: A Unique Game of Survival"

Dear Editor:

I applaud the efforts of teachers to share creative activities that aim to introduce students to the societal impacts of new technologies. The August *American Biology Teacher* Journal has such an activity that unfortunately contains several misconceptions. The article, "Genetic Screening: A Unique Game of Survival," describes a simulation game, based on the television show "Survivor," in which students secretly vote to eliminate one another from a community based on health information acquired during genetic screening, or health information that the student volunteers. Students are randomly given a card titled "Diagnosis." In the game, homosexuality is "diagnosed" as a genetic disease. First, and most importantly, homosexuality is not a disease and should not be categorized, as it is in the article, with fragile X syndrome and phenylketonuria. Second, homosexuality may have an inherit component, but the reasons why some people are gay and some are not are complex and do not appear to be due to one or two genes. (The general applicability of Dean Hamer's work on the genetics of homosexuality, as cited in the article, is not known, and his work does not apply to females.) Third, the article implies that homosexuals die of AIDS, since two homosexual example cards are given, and both die of AIDS-related complications. Although there is a high incidence of AIDS in some gay male populations in the United States, AIDS is not a disease of homosexuality (as the statistics from Africa make abundantly clear) and the vast majority of homosexuals neither contract, nor die of AIDS. These types of misconception are potentially destructive to our students and we need to keep them out of our classrooms.

Sincerely,

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Dear NABT Editors:

While I applaud creative approaches to lesson design, novelty in and of itself does not make up for lack of substance. ("Genetic Screening: A Unique Game of Survival," August 2004, Volume 66, Number 6).

For a bioethics lesson that purportedly "helps students reinforce basic genetic information and facilitates the identification and understanding of these more subtle issues," there is no indication that bioethics instruction takes place. The game scenario will most certainly elicit discussion, but to what end? There are many very good instructional strategies available to teach about genetic privacy, screening, even eugenics, that do so without the damage that a lesson like this can wreak upon students. Especially problematic in this lesson is the process of voting for the elimination of the least genetically fit. While the students are assuming roles for this activity, I know that I am not alone in having students or their family members who actually have MD, HD, mental illness, CF, Down syndrome, achondroplasia, cancer, Alzheimer's, and who are gay, overweight, or homeless. It would be a rare individual who would not feel the sting of a role they relate to being eliminated by their peers.

I request that you, as NABT editors, move to the higher ground and take a stance. Please review your articles not just for novelty, but for solid substance. Did you really mean to support articles that create roles in which homosexuality is referred to as a genetic disorder, where in the early years the role is "normal" followed by the implication that the role is no longer normal when there is an attraction to a same sex individual, and whose inevitable outcome in life is to die of complications of AIDS? Did you really mean to support articles that create roles in which a homeless mentally retarded person is referred to as a "street person"? Did you really mean to publish an article that can elicit painful discussion without providing any tools for those discussions? Did you really think about the extended implications of this "game"?

Sincerely,

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P.S. The TV program is not "Survival" as stated in the article, but "Survivor."

Response

I think I stand appropriately corrected in terms of "Survivor" rather than "Survival" in the title. This probably indicates that I am not a Survivor TV series fan. In this context, I need to remind the readers that the game, including the cards, is the creation and effort of my students. Students tend to relate to the series and to the associated societal realities related to human difference. I thought the game was creative and offered an opportunity for discussion and learning.

In terms of the game itself, the main educational intent is to allow students to respond to situations which emphasize recognition of the advantages and disadvantages of emerging biotechnologies. I am aware of some of the potential weaknesses of the game approach but hope its flexibility meets the needs of various courses and their instructors. The game rules can be modified to fit the specific course and instructor needs. For example, an instructor who wants to more closely monitor the game's direction can prepare the cards for the class in a way that directs them to more precise learning end points. Personally, I prefer a more student-oriented approach whereby students collect information and develop the cards. Cards prepared by students contain content that is questionable; however, the learning experience of card preparation is significant. Errors and/or misconceptions can be dealt with in the discussions. Although I usually scan cards before the game, I try to be very selective about requested modifications. While the game is being played, it is important that the instructor appropriately monitor the discussions to be sure that the students remain focused on acceptable topics and to correct misconceptions. The response of the class is generally enthusiastic and positive to the activity.

I do not particularly like the concept of elimination associated with the Survivor game but the students recognize is as an essential part of the TV Survivor program. Also, society does tend to be rather cruel in its response to difference. Labels, whether appropriately or inappropriately given, can influence an individual's life in both positive and negative ways. Of course, addressing discrimination is an important component of the game. For me, this game provides an opportunity to encourage development of student situational sensitivity and empathy which is frequently not done in our attempt to teach content.

Perhaps I should have avoided including the homosexuality card, however, it was generated by the students and the topic is one of interest for both major and non-major students. I do not consider homosexuality a disorder; it is a sexual preference of uncertain etiology. In the movie "Twilight of the Golds," however, homosexuality was considered to be a genetically screenable condition. The student-generated card may have been in response to that movie. During the discussion, students acknowledged that homosexuality is NOT an acceptable condition for genetic screening and associated societal discrimination. We are currently entering into a period of time when controversial aspects of genetic screening and medical labeling are being recognized and addressed. Generation of appropriate societal responses is critical.

I appreciate the specific concerns and comments of the responder. Venturing into alternative teaching is challenging. Perhaps an additional learning benefit of this method, however, is that students recognize that we all have unique differences (both genetic and environmentally based). These differences may be responded to in various ways by society as evidenced by our eugenic past, present screening efforts, and future enhancement concerns. Students need to acknowledge that the intertwining of science and society is complex and not always to the benefit of the individual. For me, the main drawback of the game is time. I recognize that the informational content could be presented in a more conventional format in a shorter period of time and possibly more selectively (based on the instructor's background and interests). The value of the game format, however, is that the students discover and deal with the more subtle societal issues and are encouraged to think and express ideas in a constructive environment.

I thank the editors for "going out on a limb" by publishing an article that involves an alternative teaching method which addresses issues related to genetic screening and societal responses to human difference.

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